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Four *Rhizocarpon* species new to China

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Abstract — Four new lichen records are reported from China — *Rhizocarpon lavatum*, *R. reductum*, *R. saurinum*, and *R. umense*. Detailed taxonomic descriptions with photos and comments are provided.

Key words — *Rhizocarpaceae*, Asia, taxonomy

Introduction

The genus *Rhizocarpon* was established by De Candolle in 1805 and is usually recognized by a crustose thallus, a usually distinct prothallus, black lecideine apothecia, *Rhizocarpon*-type asci, and hyaline to brown, halonate ascospores that can be transversely septate or submuriform to muriform (Fletcher et al. 2009, McCarthy & Elix 2014). *Rhizocarpon* species frequently occur on siliceous rocks (some on basic substrata) in extra-tropical regions, while other species are parasitic on other lichens (Matwiejuk 2008).

Rhizocarpon includes about 200 species worldwide, of which 31 species have been found in China (Aptroot 2002, Aptroot & Sparrius 2003, Guo 2005, Zhao et al. 2013). During our study of the lichen flora of China, we identified four *Rhizocarpon* species new to China, which are reported here. Two species are rather widespread and frequently reported, but the other two are rare lichens previously known only from restricted areas, one from northern Sweden and the second from North America and Iran.

Materials & methods

The examined specimens are preserved in the Lichen Section of Botanical Herbarium, Shandong Normal University, Jinan, China (SDNU) and the lichen herbarium of the Kunming Institute of Botany, Chinese Academy of Sciences, Kunming, China (KUN-L). Their morphological and anatomical characters were examined under a stereomicroscope (Olympus SZ) and a polarizing microscope (Olympus CX21). Both thallus and medulla were tested with K (10% aqueous solution of potassium hydroxide),

C (saturated solution of aqueous sodium hypochlorite), I (10% aqueous solution of aqueous potassium iodide), and P (saturated solution of *p*-phenylenediamine in 95% ethyl alcohol) for identification. The lichen substances were identified using standardized thin layer chromatography techniques (TLC) with system C (Orange et al. 2010). Photos of these lichens were taken under Olympus SZX16 and BX61 with DP72.

Taxonomic descriptions

Rhizocarpon lavatum (Ach.) Hazsl., Magyar Birodalom Zuzmó-Flórájá: 206 (1884) Fig. 1

Saxicolous. Thallus rimose to areolate, ≤1.0 cm diam.; medulla I–; prothallus black, distinct; areoles grayish white, grey or brown, contiguous or scattered, thin or medium thick, 0.20–0.40 mm diam.. Apothecia sessile or partly immersed, black, round, 0.60–1.50 mm diam., dispersed, mostly single, disc flat to slightly convex, epruinose, margin distinct, thick, ≤125 μm wide; exciple thick, 85–125 μm wide, brown in inner part, rim brownish black, K–, no crystals; epihymenium pale brown, or brown and olive-green intermixed, K–, no crystals; hymenium hyaline, 85–150 μm tall; hypothecium brown, K–; paraphyses branched and anastomosing. Asci 8-spored; ascospores persistently colorless, eumuriform, with 15–24 cells in optical view, oblong-ellipsoid, halonate, 31–40 × 12.5–13.5 μm.

Chemistry — Medulla K–, C–, P–; no substance detected by TLC.

Specimens examined: **CHINA**. **Jilin**, Baishan Co., western side of Mt. Changbai, alt. 2300 m, on rock, 22 Jul. 2014, W.C. Wang 20141093-A, 20141088, 20141123, 20141094, 20141098, 20141072, 20141059, 20141117, 20141118, 20141079, 20141080, 20141087 (SDNU); alt. 2400 m, on rock, 22 Jul. 2014, W.C. Wang 20141207 (SDNU); northern side of Mt. Changbai, alt. 1850 m, on rock, 20 Jul. 2014, W.C. Wang 20141213, 20141214 (SDNU); alt. 1950 m, on rock, 20 Jul. 2014, W.C. Wang 20141168, 20141169, 20141171, 20141172, 20141174, 20141221 (SDNU). **Yunnan**, Lijiang City, Mt. Laojun, alt. 4000 m, on rock, 7 Nov. 2009, Y.L. Cheng 20100689 (SDNU); alt. 3950 m, on rock, 25 Aug. 2015, W.C. Wang 20150101 (SDNU). **Shannxi**, Baoji City, Mt. Taibai, Doumugong, alt. 2850 m, on rock, 25 Aug. 2014, X.Y. Wang, X. Ye 14-44711 (KUN-L).

Distribution — *Rhizocarpon lavatum* has been reported from South Korea, Europe, North America, Australia, and New Zealand (McCarthy & Elix 2014, Øvstedal et al. 2009, Joshi et al. 2010). New to China.

Comments — *Rhizocarpon lavatum* was found in shaded or damp habitats, such as rocks in forests or near the river. This species is usually recognized by its numerous, large, sessile, and flat apothecia with thick margins, long narrow ascospores with many cells (15–24), and a rimose thin thallus lacking secondary substances that separates it from other *Rhizocarpon* species. *Rhizocarpon reductum* is similar to *R. lavatum* but has smaller ascospores (23–31 × 10–13.5 μm), narrower exciple (≤33 μm wide), and contains stictic acid. *Rhizocarpon timdalii* is also close to *R. lavatum* but has strongly convex

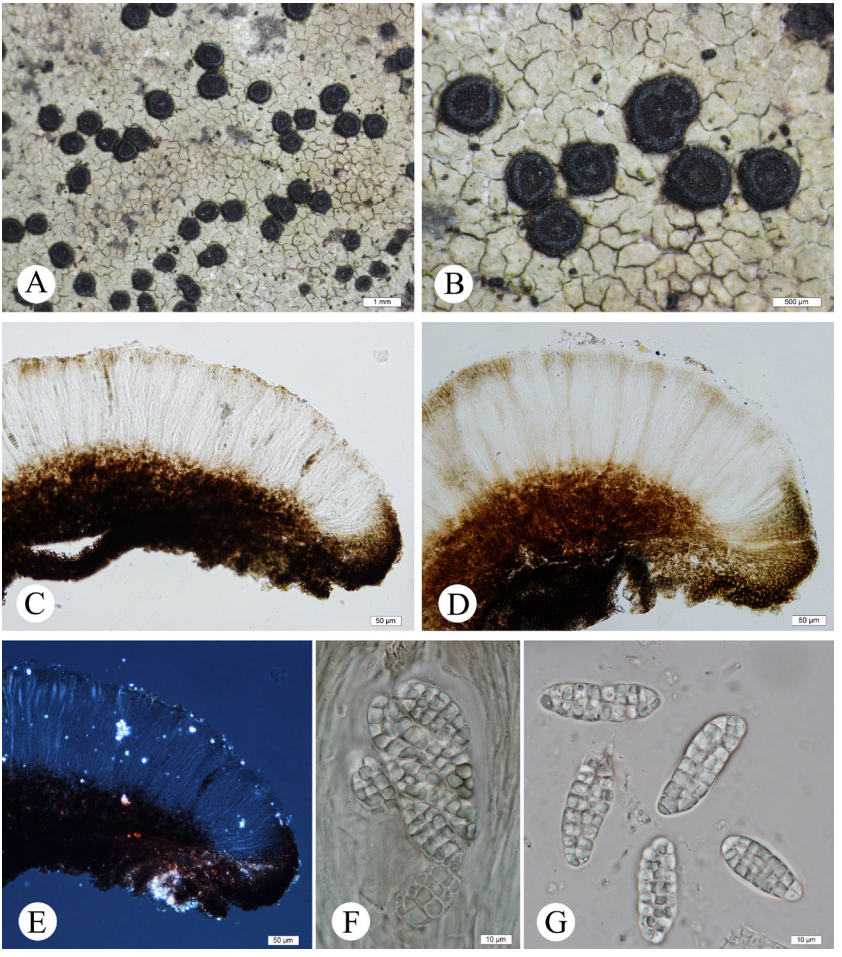

Fig. 1. *Rhizocarpon lavatum* (Wang 20141173, SDNU). A: thallus; B: apothecia; C: apothecium section; D: K reaction; E: no crystals in epihymenium and exciple; F: eight spores per ascus; G: ascospores. Scale bars: A = 1 mm; B = 500 µm; C–E = 50 µm; F, G = 10 µm.

apothecia and areoles; *R. sublavatum* is distinguished by smaller apothecia with a much thinner margin and broad ellipsoid ascospores; *R. anaperum* has a brown granular thallus and a brown epihymenium (Fletcher et al. 2009).

Rhizocarpon reductum Th. Fr., Lich. Scand. 1(2): 633 (1874) Fig. 2

Saxicolous. Thallus areolate, ≤1.0 cm diam.; medulla I–; prothallus black, present at the margin; areoles dark grey to brown, dull, usually containing

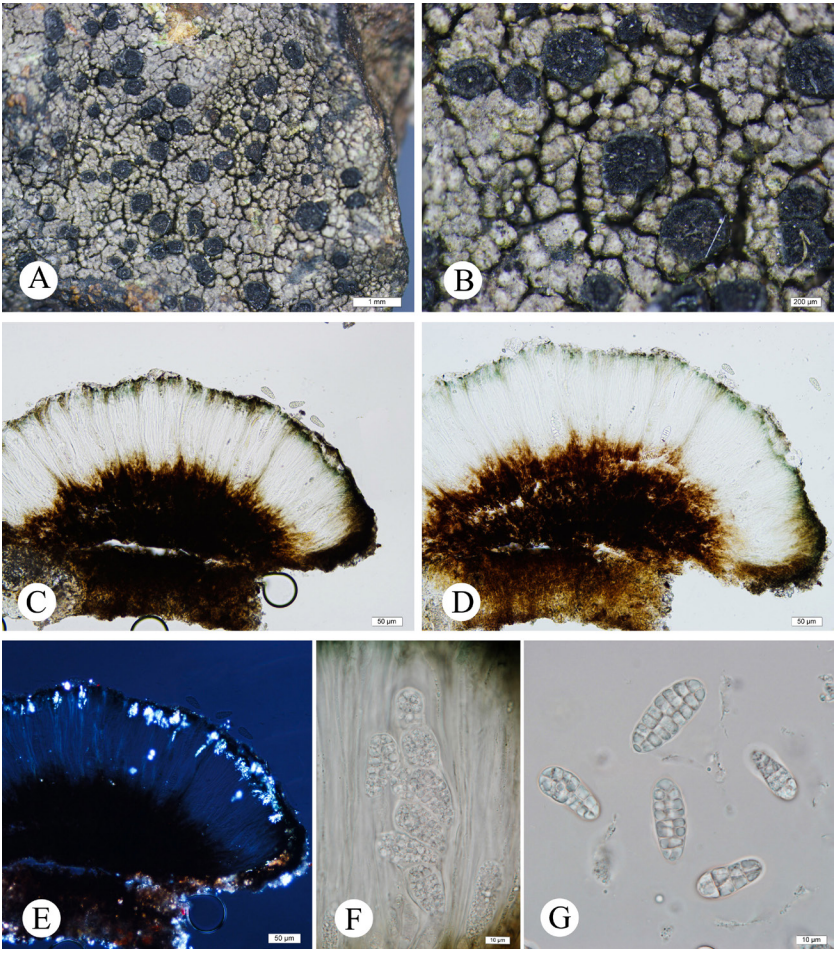

Fig. 2. *Rhizocarpon reductum* (Wang 20141075, SDNU). A: thallus; B: apothecia; C: apothecium section; D: K reaction; E: crystals in epihymenium and exciple; F: eight spores per ascus; G: ascospores. Scale bars: A = 1 mm; B = 200 µm; C–E = 50 µm; F, G = 10 µm.

granules. Apothecia black, distributed between the areolae, 0.50–0.75 mm diam., disc flat or slightly convex, rough, epruinose; exciple thin, ≤33 µm wide, brown in inner part, rim greenish black, K–, containing crystals dissolving in K; epihymenium olive-green, intermixed with brown, K–, containing crystals dissolving in K; hymenium hyaline, 108–125 µm tall; hypothecium dark brown, K–; paraphyses branched and anastomosing. Asci 8-spores; ascospores persistently colorless, muriform, with 8–18 cells in optical view, ellipsoid, halonate, 23–31 × 10–13.5 µm.

Chemistry — Medulla K+ yellow, C–, P+ orange; stictic acid detected by TLC.

Specimens examined: **CHINA**. **Shaanxi**, Baoji City, Mt. Taibai, alt. 3700 m, on rock, 5 Aug. 2005, C.L. Wang & F. Yang TBW099 (SDNU). **Jilin**, Baishan Co., western side of Mt. Changbai, alt. 2300 m, on rock, 22 Jul. 2014, W.C. Wang 20141132, 20141065, 20141075, 20141125, 20141102 (SDNU). **Xinjiang**, Urumqi City, Mt. Tianshan, Glacier No. 1, alt. 2700 m, on rock, 28 Aug. 2011, L.L. Zhang 20126751 (SDNU); Nanshan xiaoqvzi, alt. 2100 m, on rock, 28 Aug. 2011, L.L. Zhang 20126750 (SDNU); Yili City, Qiongbola National Forest Park, on rock, 12 Jun. 2014, P.M. Wang 20140109 (SDNU); Changji City, Augest First Forest Farm, alt. 2100 m, on rock, 10 Aug. 2012, X. Zhao 20129234 (SDNU). **Zhejiang**, Hangzhou City, Mt. Tianmu, Tianchi, alt. 1100 m, on rock, 20 Oct. 2010, H.Y. Wang 20104183 (SDNU).

Distribution — *Rhizocarpon reductum* has been reported from Europe, Asia, North America, Africa, Australia, and New Zealand (Feuerer 1991, Fryday 2000, Ihlen 2004, McCarthy & Elix 2014). New to China.

Comments — *Rhizocarpon reductum* is recognized mainly by the presence of stictic acid, smaller muriform ascospores, and narrower exciple. Other *Rhizocarpon* species that also contain stictic acid and have hyaline and muriform ascospores include *R. furfurosum*, *R. distinctum*, *R. petraeum*, and *R. umbilicatum*. *Rhizocarpon furfurosum* differs from *R. reductum* in having an isidiate thallus, while *R. distinctum* is distinguished by its I+ blue medulla; *R. petraeum* and *R. umbilicatum* both have a pruinose thallus. *Rhizocarpon timdalii* is close to *R. reductum* but can be separated by its blue-green epihymenium, small convex areoles, lack of stictic acid, and ascospores that are longer and broader and with more cells (Ihlen 2004). For the differences between *R. reductum* and *R. lavatum*, see Comments under *R. lavatum*.

Rhizocarpon saurinum (W.A. Weber) Bungartz, Bryologist 107: 77 (2004) Fig. 3

Saxicolous. Thallus dispersed or contiguous, ≤1.5 cm diam., granular verrucose to areolate; medulla I–; prothallus absent; areoles pale yellow, up to 1 mm diam., convex, angular or orbicular, dull. Apothecia black, round, 0.4–1.0 mm diam., convex, immersed in thalli, rough, epruinose; exciple brown-black, narrow, ≤40 μm wide, K+ violet; epihymenium brown-black, K+ violet, no crystals; hymenium hyaline and intermixed with brown, 100–125 μm tall, containing crystals, K+ violet; hypothecium brown, K–; paraphyses branched and anastomosing. Asci 8-spores; ascospores ellipsoid to globose, with 2–4–(6) cells in optical view, brown-black, halonate, 15–20 × 10–12.5 μm.

Chemistry — Medulla K–, C–, P–. rhizocarpic acid detected by TLC.

Specimens examined: **CHINA**. **Xinjiang**, Yili City, Zhaosu Co., Kuopiertigou, alt. 2436 m, on rock, 18 Jun. 2014, P.M. Wang 20140276, 20140283, 20140285 (SDNU). **Xizang**, Basu Co., Sharao village, alt. 3867 m, on rock, 18 Sep. 2014, L.S. Wang et al. 14-46374 (KUN-L).

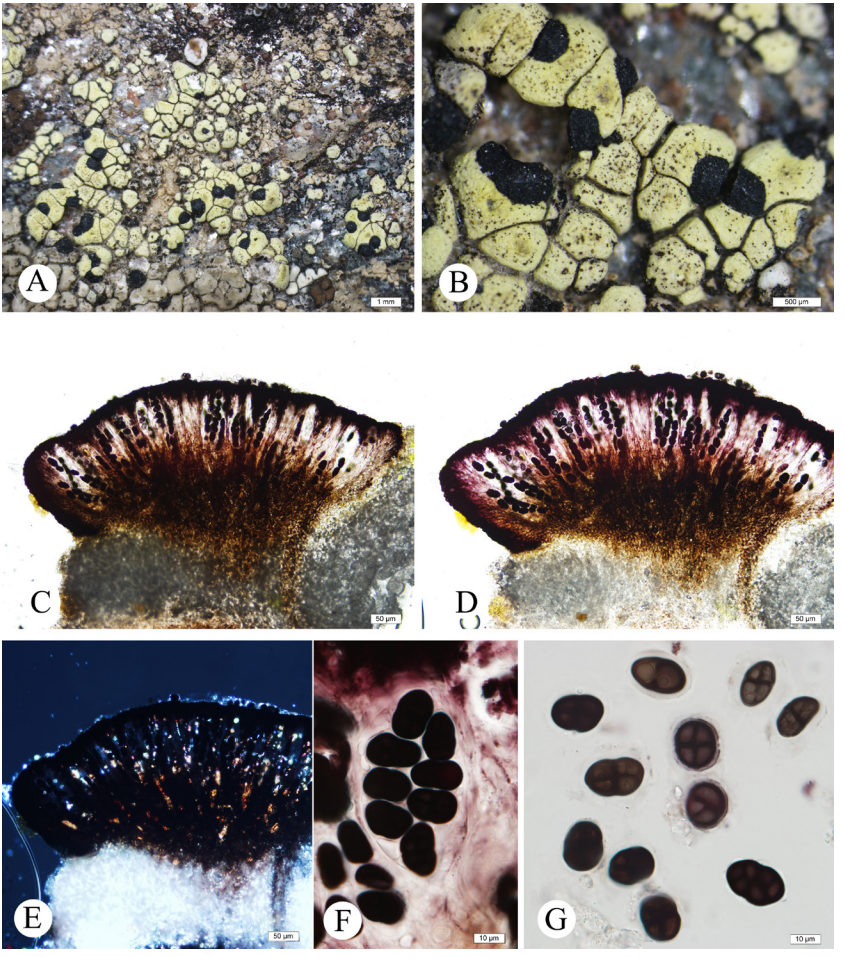

Fig. 3. *Rhizocarpon saurinum* (Wang 20140276, SDNU). A: thallus; B: apothecia; C: apothecium section; D: K reaction; E: crystals in hymenium; F: eight spores per ascus; G: ascospores. Scale bars: A = 1 mm; B = 500 µm; C–E = 50 µm; F, G = 10 µm.

Distribution — *Rhizocarpon saurinum* has been reported from North America and Iran (Bungartz & Fryday 2004, Moniri et al. 2009). New to China.

Comments — *Rhizocarpon saurinum* is recognized by its I– medulla, small 2–6 celled ascospores, brown-black K+ violet epihymenium, and containing rhizocarpic acid only (Bungartz & Fryday 2004). The similar *Rhizocarpon viridiatrum* is distinguished by its larger ascospores (15–28 × 7–14 µm) and lichenicolous (at least initially) habit.

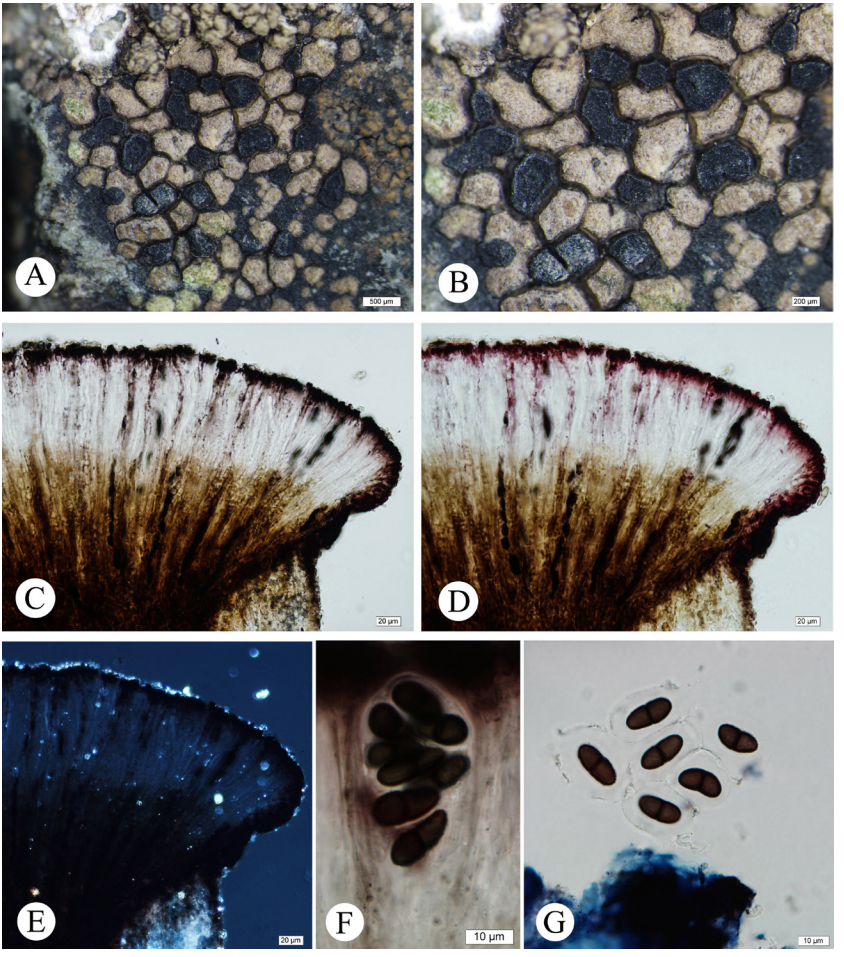

Fig. 4. *Rhizocarpon umense* (Zhang 20126751, SDNU). A: thallus; B: apothecia; C: apothecium section; D: K reaction; E: no crystals in epihymenium and exciple; F: eight spores per ascus; G: ascospores. Scale bars: A = 500 µm; B = 200 µm; C–E = 20 µm; F, G = 10 µm.

Rhizocarpon umense (H. Magn.) A. Nordin, Graphis Scripta 17(2): 37 (2005) Fig. 4

Saxicolous. Thallus areolate, small, ≤0.5 cm diam.; medulla I+ blue; prothallus black, distinct at the margin; areoles brown, 0.30–0.55 mm diam., medium thick, flat to slightly convex, angular, contiguous in the central portion but thin and scattered at the margin. Apothecia black, round to angular, multi-shaped, 0.25–0.55 mm diam., dispersed, distributed between the areolae, immersed, disc persistently flat, rough, epruinose; margin present,

thin, completely separate from areoles; exciple and epihymenium black, K+ red; hymenium hyaline below, upper part pale red, 60–90 μm tall, I+ blue; hypothecium brown, K–; paraphyses branched and anastomosing, no crystals in the apothecia. Asci 8-spores; ascospores brown, 1-septate, ellipsoid, occasionally slightly bent, halonate, 12.5–17.5 × 6–7 μm.

Chemistry — Medulla K–, C–, P–. no substance detected by TLC.

Specimens examined: **CHINA. Xinjiang**, Urumqi City, Mt. Tianshan, Glacier No. 1, alt. 2700 m, on rock, 28 Aug. 2011, L.L. Zhang 20126751, 20126752 (SDNU).

Distribution — *Rhizocarpon umense* has previously been reported only from Sweden (Nordin 2005). New to China.

Comments — *Rhizocarpon umense* is characterized by its small 1-septate brown ascospores, I+ blue medulla, K+ red epihymenium, and absence of secondary substances. The similar *Rhizocarpon alaxense* can be distinguished by its I– medulla, K– epihymenium, and rusty-ochraceous thallus.

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